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TRANSFUSION.

By JAMES R. CHADWICK, M.D.

Read at the Annual Meeting of the Massachusetts Medical Society, June 3, 1874.

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TRANSFUSION.*

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IT is not to be expected that this operation would have found much favor prior to the discovery of the circulation of blood in 1628, and yet we come across so many mentions of it in ancient writings that we are fain to admit that the idea of reänimating the vital forces by the introduction of healthy blood into the system has been a familiar one in all ages of the world. Whether transfusion was ever practised before the 17th century, we have good reason to doubt, in spite of the affirmative testimony to be derived from many incidental references in old manuscripts.

The ancient Egyptians are said to have employed this means to cure their princes. An old Jewish document records the fact that "Naam, prince of the army of Ben-Adad, King of Syria, when attacked with the leprosy, applied to his physician, who, to effect a cure, removed the blood from his veins and replaced it with other blood." Medea is represented by Ovid as offering to restore youth and strength to Pellias by replacing his aged blood with that of a young man.

Without discussing the credibility of these and similar statements, we may pass on our historical Pegasus over the Great Dismal Swamp of the middle ages without drawing rein until we reach the 17th century. In its early years, we again find attention directed to this method of treatment, but it was not until the year 1665 that Richard Lower, an Englishman, first published a complete description of the procedure to be followed in transfusion, and performed the operation upon animals. Stimulated by the accounts of his success, Denys, professor of philosophy and mathematics in Paris, after repeating the experiments on animals, at length, in two instances, successfully transfused a lamb's blood into the human circulation. The publication of his results gave rise to the most violent excitement in Paris. One party "laid claim to the discovery of a universal remedy which would restore health, youth and vigor, assuage diseases of the mind, calm the most violent dispositions, and might even prolong life beyond its natural term." Their opponents contended that not only were these pretensions false, but that the operation was always dangerous and sometimes fatal.† Laury, for instance, an eminent surgeon, maintained that certain particles of the blood were distributed to nourish certain

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† Cyclopædia of Practical Medicine. Article, Transfusion.

parts of the body, and asked what would become of those ingredients of the blood which nature intended should produce the horn of a bull, if a bull's blood were introduced into the human circulation. He also thought that the stupidity and low instincts of the animal would thus be transmitted to the man. The latter party finally prevailed by unfair means, and caused the operation to be interdicted in France, unless done with the approval of a member of the Faculty of Paris.

Upon receiving this blow, transfusion again sank into oblivion, not only in France, but in other countries.

In 1818, the great obstetrician, Blundell, revived the operation in England, and clearly demonstrated its beneficial effect in persons sinking from excessive hæmorrhage. His statements found an echo on this side of the Atlantic, in a paper written by Dr. Walter Channing, of Boston, published in the first volume of the Boston Medical and Surgical Journal, in which he strongly recommends transfusion, without, however, having practised it himself.

From that time down to the present day, transfusion has had a struggle to retain its place among the recognized resources of surgery. Milne-Edwards, Diffenbach, Bischoff, Polli, Nicholas, all strove to elevate it to a legitimate position, but it has only been during the last few years that its claims have been admitted. This result has been principally achieved by the writings and researches of Oré in France; Gesellius in Russia, Hasse in Germany, Aveling, McDonnell and Higginson in England. A fresh impulse to the study of transfusion, and to its more extensive employment, was given about a year ago by the report of a successful case made to the Obstetrical Society of London, by Dr. Aveling, and the exhibition of a very simple instrument, by means of which the blood can be transferred directly from vein to vein without the defibrination which has heretofore proved the greatest bar to its general adoption. Since then, English, French and German journals have been teeming with reports of cases, experiments, &c.

Having thus briefly glanced at the checkered history of transfusion, let us consider some of its physiological bearings. Writers upon this subject have all failed to emphasize the great distinction between the classes of cases to which the operation is applicable, and have, consequently, lost sight of the special and different indications which call for the operation in each of these classes. It will be the chief object of this paper to set forth the elementary physiological principles on which transfusion must rest, and then deduce from them some rules to guide us in the employment of this method of treatment. We all know that transfusion has been performed in acute anæmia consequent upon excessive hæmorrhage, in cholera, phthisis, cancer, chlorosis, mania, dysentery, pyæmia, septicæmia, &c. I propose to divide the cases in which transfusion may be practised, with a reasonable prospect of benefit, into four groups, basing the distinction upon universally accepted views as to the constitution of blood in health as compared with that in the various diseases which result in an altered condition of the fluid. I suggest this classification as the only one possible in the present state of science, but I foresee and predict that further researches of physiologists will render a much closer discrimination possible, and lead to a much more rational use of transfusion. Let us take up each class separately.

First, a patient, most often a woman after childbirth, has profuse

hæmorrhage; she lies motionless, moaning, bathed in a cold sweat; her pulse cannot be felt; the heart beats feebly, and threatens to cease at any moment; stimulants fail to arouse the vital forces, and we turn to transfusion as the only remaining resource whereby to rekindle the flickering spark of life. How, then, does transfusion effect this result? The first and essential indication is to keep the heart beating; but, before we can expect to accomplish this, we must understand clearly why its action is failing. Here, I believe, authors have been at fault in overlooking the chief factor. They have, so far as I know, all sought to ascribe the enfeeblement and ultimate arrest of the heart's action to the cerebral anæmia and the consequent withdrawal of the necessary stimulation. If my theory, however, is correct, the heart ceases to beat, in a great measure, under the influence of a purely physical law. Before it can contract, the heart must dilate, but this it cannot do unless the afferent veins are in condition to pour into its cavities the needed supply of blood. If they are empty, and cannot fulfil this requirement, the heart is held in a stronger than giant's grip. This condition is not produced in a moment of time; as the blood escapes from the peripheral vessels, a gradually diminishing amount returns to the heart, and thus its dilatation is more and more impeded, and, finally, its action altogether arrested. To meet this emergency, the infusion of any innocuous fluid into the vessels would suffice to free the heart from bondage, but physiology now steps in and claims for the organism a constant distribution of oxygen throughout its numerous members, and an equally uninterrupted removal of carbonic acid; these failing, we have asphyxia and speedy death. These two processes are carried on by means of the red blood corpuscles; if they are not circulating in sufficient numbers, the relative proportion of oxygen and carbonic acid in the system is disturbed, the brain consequently ceases to perform its functions, and the heart to beat. I do not mean to imply that the two laws, adduced to explain the cause of death after excessive hæmorrhage, act independently of each other. The influence of both is undoubtedly felt from the outset; but I do assert that neither can be disregarded in studying this question. Some authors strive to explain the good effect of venous transfusion by supposing that the blood "goes direct to the heart, which is stimulated to increased action by the presence of its natural stimulant;"* this explains nothing. Other processes are unquestionably carried on by the blood in its circuit, but we know of none whose interruption is immediately followed by ominous symptoms or death. They may, therefore, be practically overlooked in this category of cases. We thus have two indications to fulfil: first, fill the vessels with a fluid, so that the heart will not have to struggle vainly against one of nature's physical laws; and, secondly, let that fluid contain enough blood corpuscles to dispense oxygen and remove carbonic acid throughout all parts of the economy, in quantity proportionate to their several needs. It is evident that blood alone will meet those requirements. The presence or absence of fibrin, which has been much discussed from a physiological standpoint, is clearly of no importance, so far as the immediate demands of the system go, unless it is needed to preserve the viscosity of the blood as essential to its steady circulation—to ensure the integrity of the red corpuscles—or to prevent serous exudations. These

* Dr. Madge, in Obstetrical Journal of Great Britain, ii. 2, p. 128.

possible dangers have not been satisfactorily demonstrated as facts, so that I may venture to say that, provided coagulation of fibrine can be prevented during the blood's transit from one vascular system to the other, we may practically ignore the mooted question of defibrination.

In the second series of cases, I include those diseases such as cholera, dysentery, perhaps anasarca and other serous effusions, in all of which the watery elements alone are extracted from the blood; the vessels then partially collapse, and the heart, as before, falls a prey to nature's abhorrence of a vacuum. Many of the nutritive ingredients of the blood may, unknown to us, be lost with the serum; but the blood corpuscles remain, as does our ability to resuscitate the patient, if we can provide a means of carrying them on their errands throughout the system. Inject any fluid which will not destroy the integrity of the blood corpuscles and the patient is saved from the immediate danger. This explanation accounts for the great revival reported from the infusion of salt and water in the prostration of cholera; clear water having been shown to cause the blood corpuscles to swell, and, finally, become disintegrated. The ultimate death of most such patients, after a real, though temporary improvement, would rather indicate that the salt and water had some subsequent deleterious influence, the effect of which does not declare itself for a day or two. With a view to the permanent recovery of these patients, it will, therefore, be advisable to inject blood, until physiologists have discovered an artificial serum, devoid of all harmful properties, or until it should be found that the mass of blood corpuscles is made by transfusion so excessive as to render the blood too thick to circulate freely.

The third class embraces all those cases in which, through some occult failure of the digestive, absorptive, assimilative, or other vital processes, the blood is so wanting in nutritive elements as to be unfit to make good the waste of tissue throughout the economy. Transfusion is here resorted to for the purpose of supplying a fluid that contains every kind of food, which the system requires. I especially include every nutritious constituent, because the present position of science rarely enables us to penetrate so deeply into the mysteries, even of our physical nature, as to determine what special element is wanting to restore the blood to its normal composition in any given disease. Blood is again the only fluid which, as far as our present knowledge goes, will meet the wants of the system. The question of defibrination now assumes a vital importance, and its permissibility depends upon whether we accept the doctrine that fibrine is only one form of albumen, and thus a nutriment, or agree with other physiologists, who are led, by "its absence from the blood which has passed through the great depurating organs of the body,"* to regard it as a purely excrementitious element; in the latter case, its removal from the blood to be infused becomes an act of purification, and renders the blood better fitted to perform its functions. This last argument loses much of its force, however, when we reflect that the same office of defibrination is, by the admission of those who lay stress upon this point, thoroughly effected by a single passage of the blood through one of these depurating organs.

The fourth and last category contains those cases in which, owing to the inefficient performance of the eliminative functions, or to the

* Dr. R. McDonnell. Obstetrical Journal of Great Britain, i. 8.

introduction of injurious matter from without, the blood is so charged with noxious elements as to poison all the parts of the system through which it flows. Here our chief aim is, not to put anything into the circulation, but to take from it these pernicious ingredients. Uræmia, pyæmia, septicæmia, perhaps cancer and others, play the chief rôle among these diseases. We must remove the poison by some means, before it destroys life; this might be accomplished by banishing the source of contamination, by promoting the elimination of the poisonous substances through the natural excretory organs, by introducing into the circulation an antidote which would render the noxious elements harmless, or, finally, by substituting a healthy for an unhealthy blood, thus getting rid of the infectious ingredients. All these methods have often been known to fail; the last has been proposed as offering theoretical advantages, but I cannot learn that transfusion has proved of permanent benefit in such cases.

To sum up: Healthy blood is—physiologically speaking—the best fluid for infusion in every class (except, possibly, in the second) where the treatment is to be directed at increasing or bettering the circulating medium; but, as fresh human blood is not always to be obtained at a moment's notice, it may be well to consider whether other fluids may be used with any prospect of success. Animal blood comes up as the most natural substitute, and has been fully tested by many observers. Quite recently, Hasse, in Nordhausen, has published thirty-nine cases in which lamb's blood was transfused into man; his results showed marked improvement in fifteen cases, temporary relief in thirteen, no improvement in two, and one immediate death. Such results appear to refute conclusively the experiments and theories which would make animal serum a solvent of human blood corpuscles, or represent animal corpuscles as incompetent to carry oxygen and carbonic acid in the human circulation, because they differ in shape and size from human corpuscles. It is certainly a wise precaution always to select, as the blood-donor, a lamb or a dog, since in them the corpuscles are smaller than in man.

In the first category, blood is evidently indispensable for tranfusion, because blood alone contains the corpuscles required to distribute oxygen or remove carbonic acid. It would also seem fruitless to seek for any artificial substitute in such instances. It is different, however, with the second class, where a harmless fluid only is requisite. Experiments directed to solve the problem here involved are likely to succeed. In the third class, we practically seek to introduce already digested and perhaps assimilated food, thus relieving exhausted nature from the task of performing the process. The circulating fluid is probably not much reduced in volume, so that, before infusing new blood, we must remove some of the old, or a dangerous state of general plethora may result. Again, in this class, as in the fourth, a single transfusion, though occasionally giving nature time to rally its forces and thus turn the scale, more often fails to be crowned by marked success or failure. The cause of the depraved or contaminated state of the blood is apt to be still acting, so that the operation must be often repeated if we are to hope for a permanent good result; a single meal of digested food thus introduced, or a single abstraction of poisonous matter, avails but for the moment.

Having thus briefly shadowed forth some of the general physiologi-

cal laws on which transfusion is based, I will proceed at once to discuss the operation and the principal methods employed.

The immediate effect of injecting blood into the veins is varied; the veins swell, the skin of the arms becomes red, perspiration forms upon the face; dyspnœa and a feeling of fulness in the abdomen soon succeed the earlier symptoms. Sometimes there is vomiting, an irresistible inclination to go to stool. Finally, headache, giddiness and fainting. Pain in the back is invariable, often persisting for several days. Shivering and a rise of temperature of several degrees take place within an hour of the operation. Later, a profuse perspiration and sound sleep, from which the patient awakes much refreshed and strengthened. Albumen and hæmatin are sometimes found in the urine on the following day, but no blood corpuscles.

Dr. Madge* has formulated the principal methods as follows:—

1. Transfusion with defibrinated blood.
2. Mediate transfusion with pure blood.
3. Immediate transfusion from vein to vein.
4. Immediate transfusion from artery to vein.

1. Transfusion with defibrinated blood has thus far been the method most in vogue, its chief English advocate being Dr. Robert McDonnell, of Dublin. He regards defibrination as an essential condition, for the physiological reasons already cited, but more especially because of the rapid coagulation of pure blood and the consequent liability to the formation of small emboli, to which he attributes, rather unjustifiably I think, all the deaths which have occurred within a few days after the operation. Moreover, it has been shown that very small coagula almost invariably form, even in blood that has been whipped and strained, and that the corpuscles in such blood adhere together in rolls, and are, not improbably, altered by the treatment to which they have been subjected. Finally, it may be objected that of seventy transfusions with defibrinated blood, only eighteen have been successful.† Dr. McDonnell has operated in several cases, with three or four favorable results. His procedure is to catch the blood in a basin, and whip it with a stick, or better still on the grounds of cleanliness, with a glass rod. In two or three minutes, the fibrine is found adhering to the rod, when the blood must be strained several times through fine linen. It is then ready for use, and is placed in a glass cylinder, capable of holding six ounces, shaped like a syringe, but devoid of a piston; to the nozzle is affixed a long rubber tube, with a canula at its extremity for insertion in the vein. The blood is driven into the vein by gravitation, aided by a small propelling bulb in the middle of the tube, and the occasional gentle blowing of the operator, with his mouth applied to the open top of the cylinder.

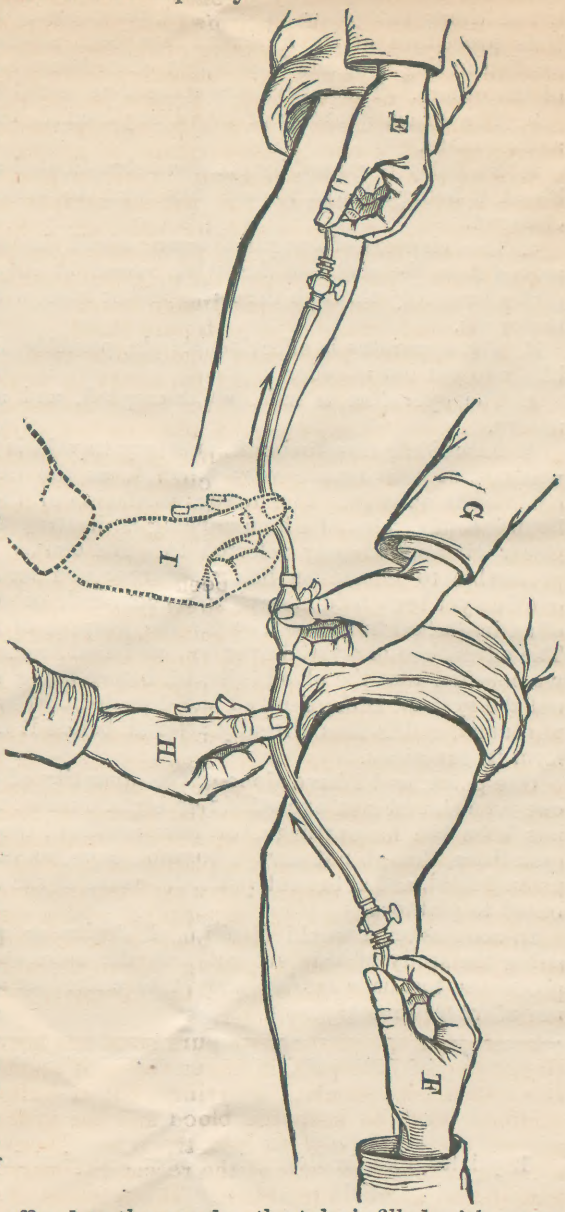
2. Mediate transfusion with pure blood has been performed by Mr. Higginson, of Liverpool, in fifteen cases, of which ten were successful. His instrument resembles a syringe, but is bulky, owing to the precautions taken to keep the blood and the instrument warm, and to prevent the entrance of air into the vein. These contrivances would seem superfluous, in view of the recent discovery that heat promotes coagulation, and cold retards it. The entrance of air into the veins is, moreover, not now regarded with the same apprehension as of old,

* British Medical Journal, January 20, 1874.

† Gesellius. Die Transfusion des Blutes, p. 109. St. Petersburg, 1873.

for Oré has shown that, although a large quantity of air, forced into the femoral vein of a dog, will cause death in a few minutes, a small quantity may be introduced with impunity.*

3. Immediate transfusion from vein to vein has been revived and perfected by Dr. Aveling,† whose instrument as he very justly remarks forms an anastomosis between the circulatory system of the two individuals (they become Siamese twins for the time being). It consists of a rubber tube, about a foot long, with a bulb at the centre. Two canulæ are inserted into one of the larger brachial veins of the patient and of the blood-donor respectively—the former being directed toward the heart to discharge the blood, and the latter toward the periphery so as to receive it. There are no valves to the pump, for fear they might become centres for the formation of fibrinous clots; as a substitute for them, the finger and thumb of the left hand are made to compress the tube on one or the other side of the bulb, according as the bulb is expected to forward its contents toward the patient or to re-fill itself from the veins of the donor. Before being affixed to the canulæ, the tube is filled with warm



* Etudes sur la Transfusion du Sang. Paris, 1868.
† Obstetrical Journal of Great Britain, i. 5 and 6.

water, so that the first syringeful injected is pure water; this has not proved deleterious. This process is repeated as often as is thought desirable, the amount of blood transfused being gauged by the number of times the pump is emptied, its capacity being two drachms. This procedure of Dr. Aveling's has been seven times successfully applied in England, and it certainly offers more advantages than any of the others. These advantages are thus stated by the author:—

a. The exact quantity of blood required is taken from the donor, and no more.

b. No delay is caused by previous complicated manipulations of the blood, it being allowed to pass from vein to vein physiologically unchanged.

c. The chances of coagulation are small, because the blood is removed from the action of the living vessel for only a few seconds, and glides smoothly through the India-rubber tube, without being exposed to the air.

d. The apparatus is effective, simple, portable, inexpensive, and not likely to get out of order.

e. The operation is safe, uninterrupted, and a close imitation of nature.

4. Immediate transfusion from artery to vein is the oldest form, and was not, at the outset, very difficult, as the early operations were confined to animals. The direct transfusion of the arterial blood of a lamb into the veins of a human being is illustrated by the cases of Dr. Oscar Hasse,* already referred to. He claims that lamb's blood is preferable to human as being stronger and more stimulating. No one has yet been bold enough to recommend, or practise the opening of an important human artery for the purpose of arterial transfusion. The advantage of arterial over venous blood seems questionable, when we consider that the blood injected, before being distributed throughout the system, is oxygenated and decarbonized by its passage through the lungs, and is thus virtually arterial before it is called upon to perform its functions.

One point, and I have done. The quantity of blood transfused at one time should not exceed six or eight ounces, no matter how great has been the hæmorrhage, or how profound the prostration; larger quantities, though not always harmful, have, on one or two occasions, proved fatal, and at the autopsies the cause of the death has been attributed to plethora.

In conclusion, I would disclaim all desire or qualification for pursuing the study of this subject into the more abstruse physiological processes, but have merely sought to make out a rough chart for the use of future investigators.

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* Vide Allgemeine Wiener Medizinische Zeitung for December, 1873.

Reprinted from the Boston Medical and Surgical Journal, July 9, 1874.